



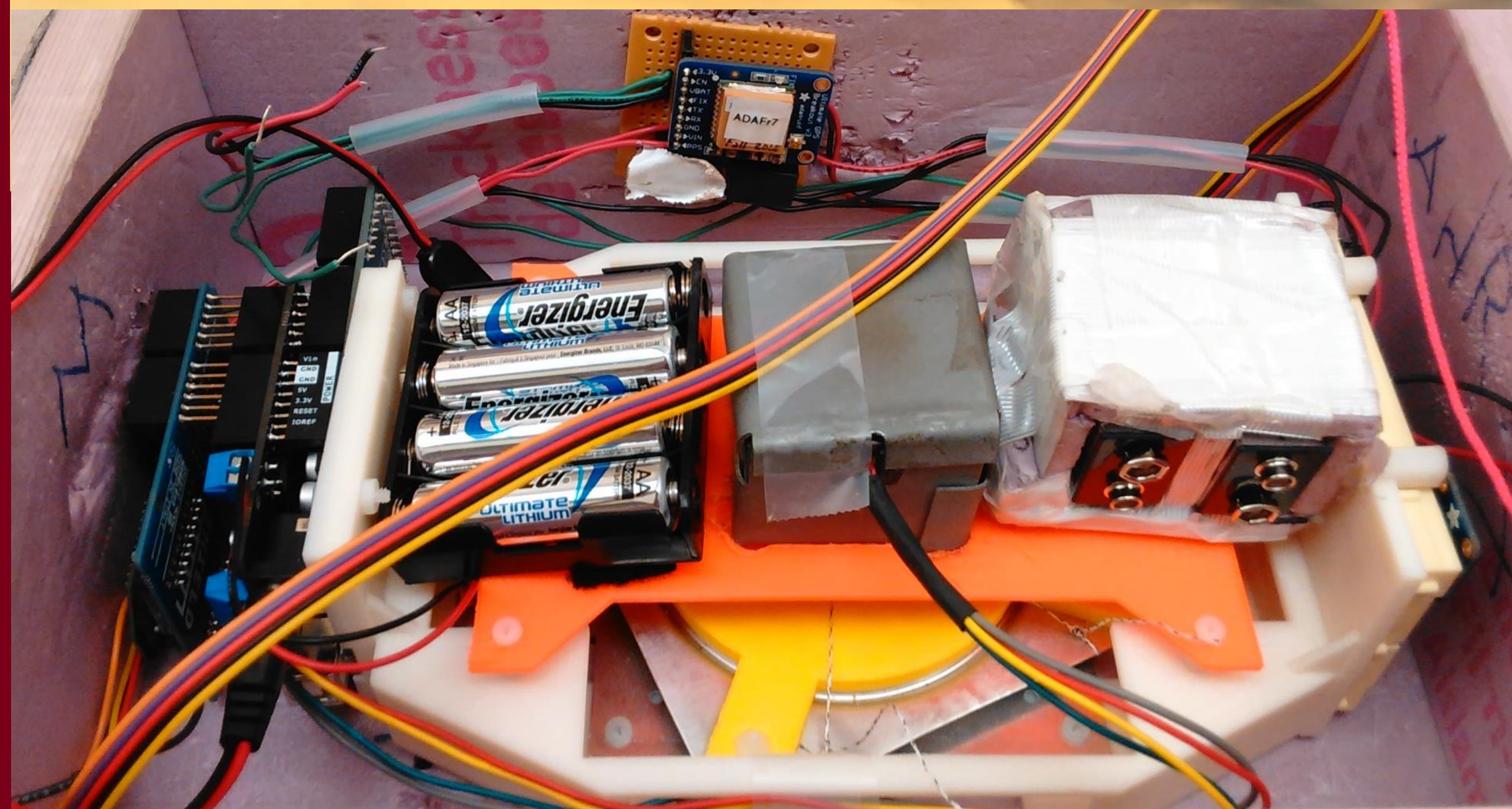
Improving the “Active Heading Control Platform” (CHAD) for Active Experiment Pointing During Stratospheric Balloon Flights

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Abstract

Payloads carried into the stratosphere using weather balloons typically spin and sway during ascent, limiting the types of experiments that can be performed. This project aimed to improve the functionality and performance of the Arduino-controlled active anti-rotation camera platform called CHAD (Controlled Heading Automation Device) that was reported upon at AHAC 2016 by Andrew Kruger from Wilbur Wright College in Chicago¹. The CHAD device senses its orientation using a magnetometer and an inertial measurement unit, then counters rotation by turning its main shaft with a stepper motor so as to hold fixed the absolute heading of the attached experiment (such as a video camera). The goals of this project were to make CHAD more low-temperature tolerant and to expand its functionality with gps sensing and radio commanding.



Top: Frame from a CHAD-pointed video payload during the eclipse.
Bottom: Top view of the inside of a CHAD payload.

References

1. Kruger, A., Maksimowicz, R., Zaheer, M., Almaraz-Vega, A., Urquiza, J., “Active Heading Control Platform for Instruments Flown on High Altitude Balloons”, <http://www.physi.cz/uploads/2/0/5/6/20564332/chad.pdf>

Additions/Upgrades

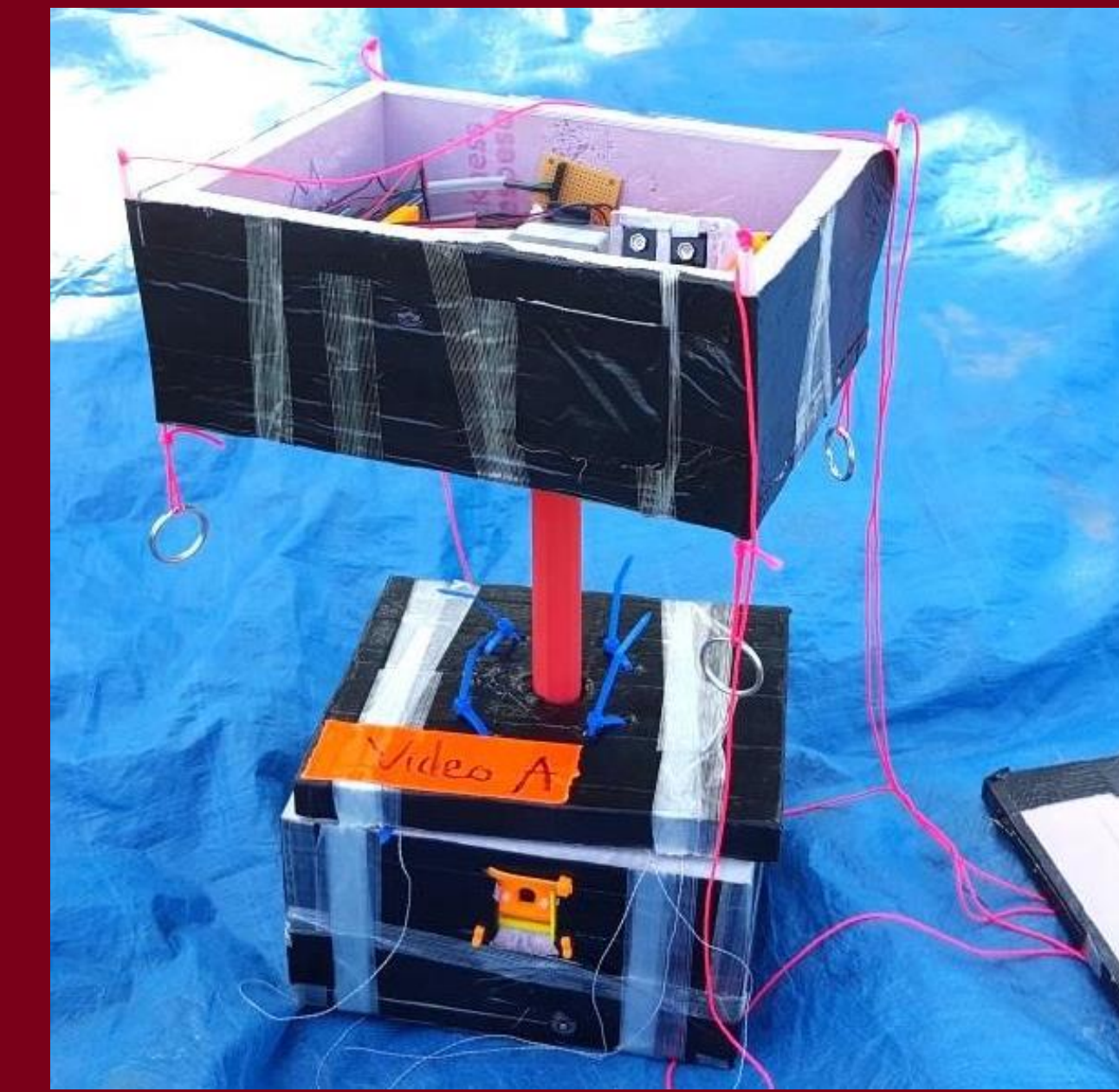
- Modular Incremental Encoder (AMT102)
Senses the angle through which the shaft actually turns, creating a feedback line for the microcontroller.
- Arduino Mega
Increased memory allows for a larger program and more serial lines for hardware.
- Arduino Wireless SD-logging Shield w/ Series 1 XBee
SD logging aids in troubleshooting and the XBee allows remote control through a communication relay payload.
- Resets
Reset pins are cross-linked so each microcontroller can reset the other. Resets are controlled through XBee commands (and autonomously for the Arduino Micro).
- Adafruit Ultimate GPS Breakout
Allows altitude-base autonomous operation. Could be used to point toward specific targets while in flight.

Project Overview and Testing

Our modified CHAD has shown fairly successful results in some of its later flights. During earlier flights the heading system stopped working part way through the ascent, as was also reported by the Chicago team that originally developed CHAD. During the second flight XBee communication was maintained throughout the flight and heading functionality lasted longer than during the first flight. Later flights offered even better results, but some rotation still persisted.

Ground Testing

- Cold-Soak Testing
 - Stepper motor alone: Functioned properly even in a cold-soak (dry ice) chamber.
 - Full system without thermal protection: The system would fail quickly (within minutes), but keeping the batteries warm improved the performance.
- Duration Testing – After the system was turned on the Arduino Micro would sometimes stop sending orientation data to the Arduino Uno (later a Mega), but at irregular times. Watching for inactivity then sending a reset of the Micro (autonomously) would usually return the system to normal.

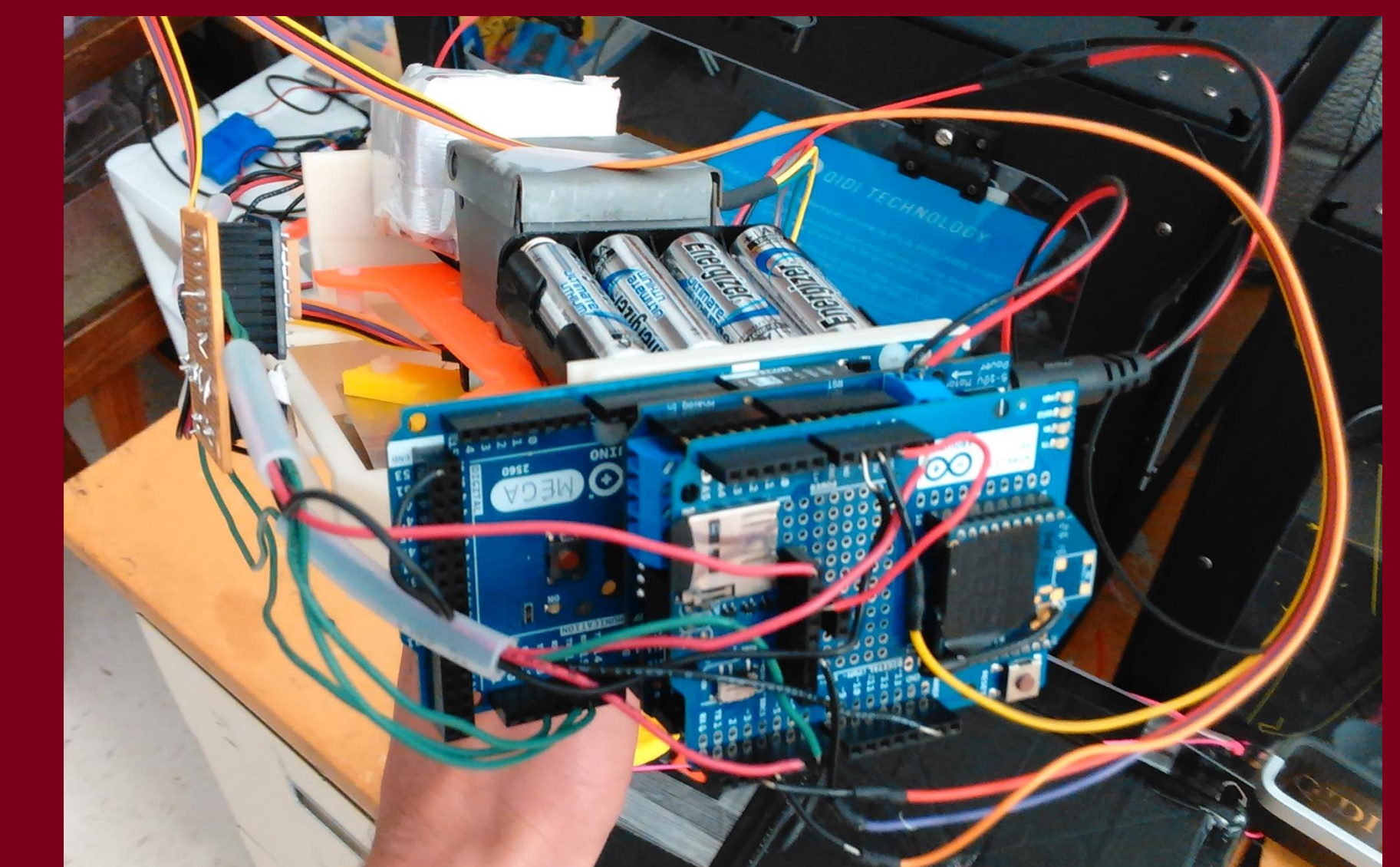
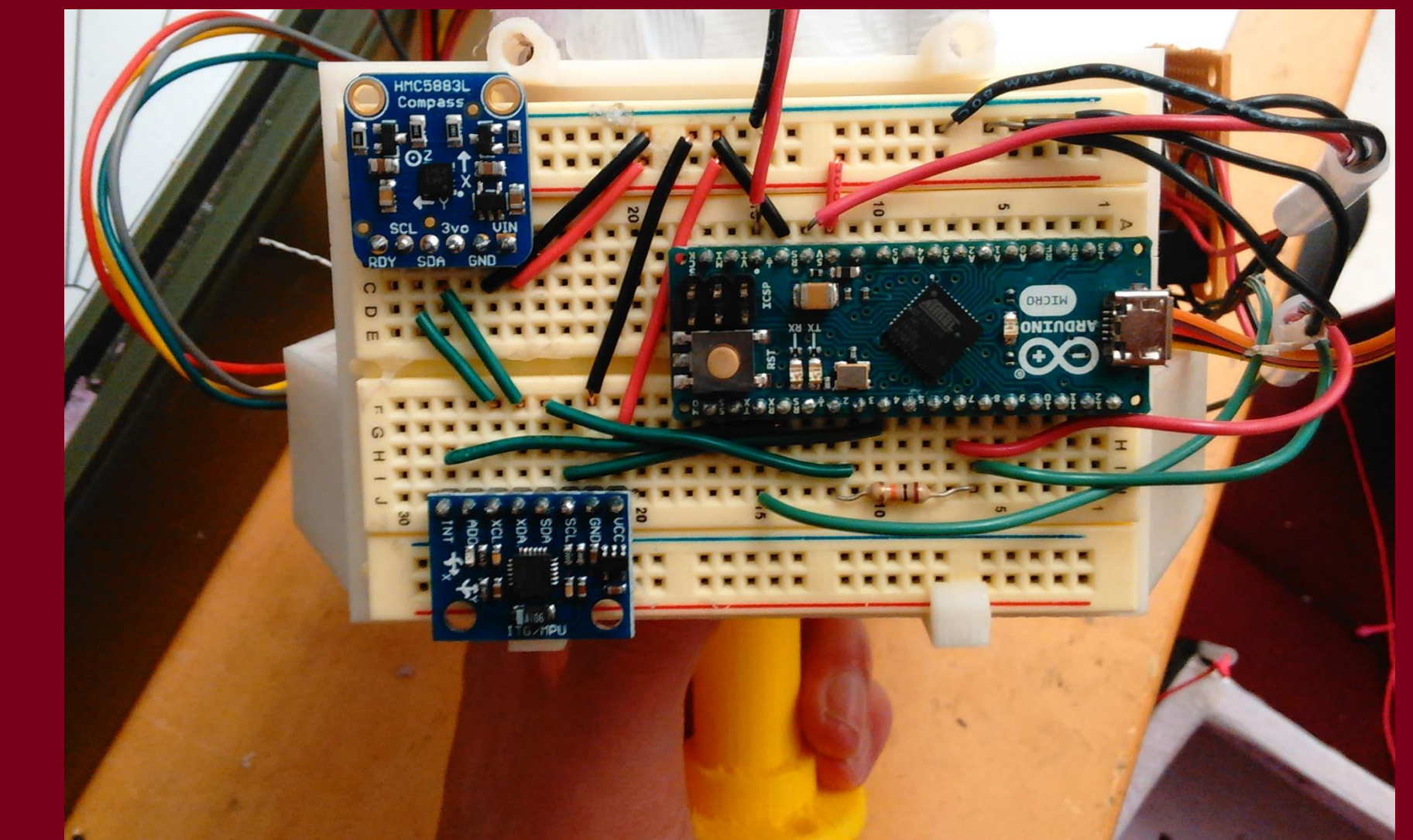


CHAD supporting a video-telemetry payload

- Strength Testing – When 38 oz of dummy weights were attached to the mounting arm (the weight of a video-telemetry payload), CHAD had no noticeable issues dealing with the increased load.
- When a real video-telemetry payload was attached to the shaft there were noticeable issues until the payload was balanced.

In-Flight Testing

- Communication – CHAD was able to respond to XBee commands relayed from the ground during the second flight, even after the heading control stopped responding.
- Resets – Automated resets appeared to work and were logged at each occurrence in-flight. A ground-commanded reset was not tested while in-flight



Orientation sensors monitored by an Arduino Micro (top). XBee radio w/SD logging and stepper motor shield attached to an Arduino Mega (bottom). The Micro relays orientation to the Mega which points the shaft using the stepper motor. Overall heading can also be commanded by XBee by radio link to the ground.

Future Plans

Future plans for CHAD include more testing with the recently-added encoder plus additional cold testing of the magnetometer . The magnetometer used in this project may need to be exchanged with a different magnetometer since the original model has been discontinued.

The CHAD project continues to show promise, with successful ground testing and partial success in flight actively pointing a payload. Additional testing needs to be done on the autonomous and commanded functionality now available due to the addition of the gps and the Xbee radio.

Acknowledgements

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